

WHAT IS CLAIMED IS:

1. An infrared reflective coated article comprising:

a substrate;

5 a dielectric layer sputter deposited over the substrate, the layer comprising a first zinc stannate film deposited over the substrate having zinc in weight percent range of equal to and greater than 10 and equal to and less than 90, and tin in the weight percent range of equal to and less than 90 and equal to and greater than 10, and an electrical enhancing film deposited over the zinc stannate film, the electrical enhancing film selected from the group of films consisting of zinc oxide, tin oxide film and a second zinc stannate film wherein the composition of the first zinc stannate film is at least about 5 weight percent different

10 an infrared reflective layer deposited on the dielectric layer,

15 a metal primer layer over the infrared reflective layer;

20 a second dielectric layer over the primer layer; and a protective layer of at least two films selected from metal-containing and/or silicon-containing films selected from: metal and/or silicon and metal-oxy and/or silicon oxy-materials where the oxy materials are selected from oxides and oxynitrides and where the metal is the same or different and selected from a transition metal of Group , 4, 5, 6 or 10 of the Periodic Table of Elements.

2. The coated article of claim 1 wherein the infrared reflective metal is silver and the silver is deposited on the zinc oxide, tin oxide film.

3. The article stack of claim 1 wherein the infrared reflective layer is a silver film and the silver film is deposited on the second zinc stannate film.

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4. The article stack of claim 1 wherein the dielectric layer is a first dielectric layer and the infrared reflective layer is a first infrared reflective layer and further including:

a metal primer layer over the first infrared reflective layer;

a second dielectric layer over the primer layer and the protective layer is a overcoat over the second dielectric layer.

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5. The article of claim 4 wherein the second dielectric layer is a zinc stannate film having 10-90 weight percent zinc and 90-10 weight percent tin.

6. The article of claim 1 wherein the dielectric layer is a first dielectric layer and the infrared reflective layer is a first infrared reflective layer and further including:

a first metal primer layer over the first infrared reflective metal layer;

a second dielectric layer including over the first primer layer;

a second infrared reflective layer over the second dielectric layer;

a second metal primer layer over the second infrared reflective layer;

a third dielectric layer including over the second metal primer layer; and

the protective layer is over the third dielectric layer.

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7. The article of claim 6 wherein at least one of the second and third dielectric layers includes a zinc stannate film having 10-90 weight percent zinc and 90-10 weight percent tin.

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8. The coating stack of claim 1 wherein the dielectric layer is a first dielectric layer and the infrared reflective layer is a first infrared reflective layer and further including:

5 a first metal primer layer over the first reflective layer;

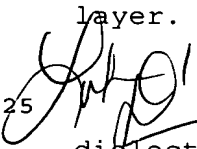
a second dielectric layer over the first metal primer layer, the second dielectric layer comprising a first dielectric film and a zinc stannate film defined as a first
10 zinc stannate film, the first zinc stannate film having zinc in the weight percent range of equal to and greater than 10 and equal to and less than 90 and tin in the weight percent range of equal to and greater than 10 and equal to and less than 90, the first dielectric layer deposited over the first
15 metal primer layer;

a second infrared reflective layer deposited over the second dielectric layer;

a second metal primer layer deposited over the second infrared reflective layer;

20 a third dielectric layer deposited over the second primer layer; and

the protective layer is over the third dielectric layer.

25  9. The coating stack of claim 8 wherein the first dielectric film of the second dielectric layer comprises a zinc oxide film; a zinc oxide, tin oxide film or a zinc stannate film defined as a second zinc stannate film, the second zinc stannate film having a composition different than
30 the composition of the first zinc stannate film of the second dielectric layer.

10. The coating stack of claim 9 wherein the second zinc stannate film of the second dielectric layer has
35 zinc in the weight percent range of equal to and greater than 60 and equal to and less than 90 and tin in the weight percent

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of equal to and greater than 10 and equal to and less than 40, and the third dielectric layer is a zinc stannate film.

11. The coating stack of claim 1 wherein the
5 dielectric layer is a first dielectric layer and the infrared reflective layer is a first infrared reflective layer and further including:

a first metal primer layer over the first reflective layer;

10 a second dielectric layer over the first metal primer film;

a second infrared reflective layer over the second dielectric layer;

15 a second metal primer layer over the second infrared reflecting metal layer;

a third dielectric layer over the second metal primer layer, the third dielectric layer comprising a first dielectric film and a zinc stannate film defined as a first zinc stannate film, the first zinc stannate film having zinc
20 in a weight percent with the range of equal to and greater than 10 and equal to and less than 90 and tin within the weight percent range of equal to and less than 90 and equal to and greater than 10, the third dielectric film deposited over the second metal primer; and

25 the protective layer overlies the third dielectric film.

12. The article of claim 11 wherein the first dielectric film of the third dielectric layer is selected from
30 the group consisting of a zinc oxide film; a zinc oxide, tin oxide film or a zinc stannate film defined as a second zinc stannate film, the second zinc stannate film having a composition different than the composition of the first zinc stannate film of third dielectric layer.

35 13. The article of claim 12 wherein the second zinc stannate film of the third dielectric layer has zinc in

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the weight percent range of equal to and greater than 60 and equal to and less than 90 and tin in the weight percent range of equal to and greater than 10 and equal to and less than 40.

5 14. The article of claim 1 wherein the dielectric layer is a first dielectric layer and the infrared reflective layer is a first infrared reflective layer and further including:

10 a first metal primer layer over the first reflective layer;

15 a second dielectric layer over the first metal primer layer, the second dielectric layer comprising a first dielectric film and a zinc stannate film defined as a first zinc stannate film, the first zinc stannate film having zinc in a weight percent within the range of equal to and greater than 10 and equal to and less than 90 and tin within the weight percent range of equal to and less than 90 and equal to and greater than 10, the second dielectric layer deposited over the first metal primer layer;

20 a second infrared reflective layer over the first zinc stannate film of the second dielectric layer;

 a second metal primer layer over the second infrared reflective layer;

25 a third dielectric layer over the second metal primer layer, the third dielectric layer comprising a first dielectric film and a zinc stannate film defined as a first zinc stannate film, the first zinc stannate film having zinc in a weight percent within the range of equal to and greater than 10 and equal to and less than 90 and tin within the weight percent range of equal to and less than 90 and equal to and greater than 10, the third dielectric layer deposited over the second metal primer layer; and

30 the protective layer overlies the first zinc stannate film of the dielectric layer.

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15. The coating stack of claim 14 wherein the first dielectric film of the second dielectric layer and the

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first dielectric film of the third dielectric layer each has a film selected from the group consisting of zinc oxide film; zinc oxide, tin oxide film or second zinc stannate film having a composition different than the composition of the first zinc stannate film in the respective same second or third dielectric layer.

16. The coating stack of claim 15 wherein the second zinc stannate film of the first and second dielectric layer each include zinc in the weight percent range of equal to and greater than 60 and equal to and less than 90 and tin in the weight percent of equal to and greater than 10 and equal to and less than 40.

17. The coating stack of claim 14 wherein the second dielectric layer further includes a third dielectric film over the first zinc stannate film of the second dielectric layer.

18. The coating stack of claim 15 wherein the second dielectric layer further includes a third dielectric film over the first zinc stannate film of the second dielectric layer wherein the third dielectric film of the second dielectric layer is a film selected from the group consisting of zinc oxide film, zinc oxide, tin oxide film and a zinc stannate film defined as a third zinc stannate film, the third zinc stannate film has a composition different than the composition of the zinc stannate film of the second dielectric layer closest to the third zinc stannate film.

19. The coating of claim 15 wherein the second dielectric film of the second dielectric layer and the second dielectric film of the third dielectric second layer each comprises a zinc oxide film; a zinc oxide, tin oxide film or a second zinc stannate film having a composition different than the composition of the first zinc stannate film of third dielectric layer.

20. The coating stack of claim 19 wherein the first and third dielectric films of the second dielectric layer and the first dielectric film of the third dielectric layer each include zinc in the weight percent range of equal to and greater than 60 and equal to and less than 90 and tin in the weight percent of equal to and greater than 10 and equal to and less than 40.

21. The coating stack of claim 17 wherein the second zinc stannate film of the first dielectric layer is on the glass piece and has a thickness in the range of 230 ± 40 Angstroms Å; the first zinc stannate film of the first dielectric layer is on the second zinc stannate film of the first dielectric layer and has a thickness in the range of 80 ± 40 Å; the first infrared reflective metal layer is a first silver film deposited on the first zinc stannate film of the first dielectric layer and has a thickness in the range of 110 ± 30 Å, the metal primer layer is a titanium film deposited on the first silver layer and has a thickness in the range of $17-26$ Å; the first dielectric film of the second dielectric layer is deposited on the titanium film and has a thickness in the range of 80 ± 40 Å; the first zinc stannate film of the second dielectric layer is deposited on the first dielectric film of the second dielectric layer and has a thickness in the range of 740 ± 40 Å; the second infrared reflective metal layer is a second silver film deposited on the second dielectric film of the second dielectric layer and has a thickness in the range of 110 ± 38 Å; the second primer film is a titanium film deposited on the second silver layer and having a thickness in the range of $18 - 31$ Å; the first dielectric film of the third dielectric layer is deposited on the second titanium film and has a thickness in the range of 80 ± 40 Å; the first zinc stannate layer of the third dielectric layer is deposited on the first dielectric film of the third dielectric layer and has a thickness in the range of 120 ± 40 Å, and the protective layer is a titanium metal film deposited on the first zinc

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~~stannate layer of the third dielectric layer and has a
thickness in the range of $29 \pm 3\text{\AA}$.~~

22. The coating stack of claim 1 wherein the
5 protective layer has at least two films selected from a metal
of titanium, zirconium, niobium, tantalum, chromium, nickel
and alloys thereof, and a metal oxy material selected from:
titanium oxides, titanium oxynitride, zirconium oxides,
zirconium oxynitrides, niobium oxides, niobium oxynitrides,
10 tantalum oxide, tantalum oxynitride, chromic oxides, chromic
oxynitrides, nickel oxide, nickel oxynitride, silicon oxide,
silicon dioxide, silicon aluminum nitride and combinations or
mixtures of any two or more of these, where either the
silicon, metal or the metal oxy material is the first film of
15 the layer.

23. A coated article comprising:
a substrate;
a first dielectric layer over the substrate;
a first infrared reflective layer over the first
20 dielectric layer;
a first metal primer layer over the first infrared
reflective layer;
a second dielectric layer over the first metal primer, the
25 second dielectric layer having a first dielectric film
selected from the group consisting of zinc oxide, tin oxide
film and a first zinc stannate film, and a second dielectric
film the second dielectric film having a composition different
than the first dielectric film of the second dielectric layer;
30 a second infrared reflective layer over the second
dielectric layer;
a second primer layer over the second reflective
layer;
a third dielectric layer over the second metal
35 primer layer; and

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a protective layer of at least two films selected from metal-containing and/or silicon-containing films selected from: metal and/or silicon and metal-oxy and or silicon oxy-materials where the oxy materials are selected from oxides and oxynitrides and where the metal is the same or different and selected from a transition metal of Group , 4, 5, 6 or 10 of the Periodic Table of Elements..

24. The coated article of claim 23 wherein the first dielectric layer includes a zinc stannate film, the second dielectric film of the second dielectric layer is a zinc stannate film and the third dielectric layer includes a zinc stannate film, each of the zinc stannate films having zinc in the weight percent range of 10-90 and tin in the weight percent range of 90-10.

25. The coated article of claim 24 wherein the first dielectric film of the second dielectric layer is the first zinc stannate film having zinc in the weight percent range of equal to and greater than 90 and equal to and less than 60 and tin in the weight percent range of equal to and greater than 10 and equal to and less than 40.

26. A coated article comprising:
a substrate;
a first dielectric layer over the substrate;
a first infrared reflective layer over the first dielectric layer;
a first metal primer layer over the first infrared reflective layer;
a second dielectric layer over the first metal primer layer;
a second infrared reflective layer over the second dielectric layer;
a second metal primer layer over the second reflective metal layer;

a third dielectric layer having a first dielectric film selected from the group consisting of zinc oxide film; zinc oxide, tin oxide film; a first zinc stannate film and a second dielectric film overlying the first dielectric film, the second dielectric film having a composition different from the first dielectric film; and

the protective layer overlying the third dielectric layer where the protective layer is at least two films selected from metal-containing and/or silicon-containing films selected from: metal and/or silicon and metal-oxy and or silicon oxy-materials where the oxy materials are selected from oxides and oxynitrides and where the metal is the same or different and selected from a transition metal of Group , 4, 5, 6 or 10 of the Periodic Table of Elements.

27. The coated article of claim 26 wherein the first and second dielectric layers are each a zinc stannate film, and the second dielectric film of the third dielectric layer is a zinc stannate film and each of the zinc stannate films has zinc in the weight percent range of 10-90 and tin in the weight percent range of 90-10.

28. The coated article of claim 27 wherein the first dielectric film of the second dielectric layer has zinc in the weight percent range of equal to and greater than 90 and equal to and less than 60 and tin in the weight percent range of equal to and greater than 10 and equal to and less than 40.

29. A coated article comprising:
a substrate;
a first dielectric layer over the substrate;
a first infrared reflective layer over the first dielectric layer;
a first primer layer over the first reflective metal layer;

a second dielectric layer having a first dielectric film selected from the group consisting of zinc oxide, tin oxide film and a first zinc stannate film, and a second dielectric film overlying the first dielectric film having a composition different than the first dielectric film of the second dielectric layer;

a second infrared reflective layer over the second dielectric layer;

a second primer layer over the second reflective layer;

a third dielectric layer over the second metal primer layer, the third dielectric layer having a first dielectric film selected from the group consisting of a zinc oxide, tin oxide film and a first zinc stannate film and a second dielectric film, the second dielectric film of the third dielectric layer have a composition different than the composition of the second dielectric film of the third dielectric layer; and

the protective layer overlying the third dielectric layer where the protective layer is at least two films selected from metal-containing and/or silicon-containing films selected from: metal and/or silicon and metal-oxy and or silicon oxy-materials where the oxy materials are selected from oxides and oxynitrides and where the metal is the same or different and selected from a transition metal of Group , 4, 5, 6 or 10 of the Periodic Table of Elements..

30. The coated article of claim 31 wherein the first dielectric layer, the second dielectric film of the second and third dielectric layers are each a zinc stannate film having zinc in the weight percent range of 10-90 and tin in the weight percent range of 90-10.

31. The coated article of claim 32 wherein the first dielectric film of the second and third dielectric layers are each a zinc stannate film having zinc in the weight percent range of equal to and greater than 90 and equal to and

less than 60 and tin in the weight percent range of equal to and greater than 10 and equal to and less than 40.

R-126

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~~34.~~ The coated article of claim ³⁰~~32~~ wherein the
5 coated article is a transparency.

R-126

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~~35.~~ The coated article of claim ³²~~34~~ wherein the
coated article is an automotive transparency.

R-126

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~~36.~~ The coated article of claim ³³~~35~~ wherein the
automobile transparency is an automotive windshield having a
pair of glass sheets laminated together and one of the sheets
is fabricated from the substrate having the coating.

R-126

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~~37.~~ A method of making an automobile transparency
comprising:

applying a coating on a glass substrate having the
following:

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a first dielectric layer over a glass substrate;
a first infrared reflecting metal layer over the
first dielectric film:

a first metal primer layer over the first reflective
layer;

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a second dielectric layer over the first metal
primer layer;

a second infrared reflective layer over the second
dielectric layer;

a second metal primer layer over the second infrared
reflective layer;

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a protective layer overlying the first zinc stannate
film of the third dielectric layer where the protective layer
is at least two films selected from metal-containing and/or
silicon-containing films selected from: metal and/or silicon
and metal-oxy and or silicon oxy-materials where the oxy-

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materials are selected from oxides and oxynitrides and where
the metal is the same or different and selected from a

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transition metal of Group , 4, 5, 6 or 10 of the Periodic Table of Elements.,

wherein at least one of the dielectric layers includes a first dielectric film selected from the group consisting of zinc oxide, tin oxide and a first zinc stannate film and a second dielectric film including a second zinc stannate film having a composition different than the first zinc stannate film and a composition of 10-90 weight percent zinc and 90-10 weight percent tin;

10 processing the coated substrate to provide a coated windshield blank wherein the processing step includes heating the coated substrate to its bending temperature and after heating the coating has reduced haze;

laminating the coated blank to another piece of
15 glass to provide the automobile windshield.

R-126

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~~36.~~ A coated article comprising:

a substrate;

at least one dielectric layer over the substrate;

20 at least one infrared reflective layer over the first dielectric layer;

optionally a first metal primer layer over the first infrared reflective layer;

optionally a second dielectric layer over a first
25 metal primer; and

at least one protective layer selected from (A) a heat convertible metal film wherein the metal is selected from titanium, zirconium, niobium, tantalum, chromium, nickel and alloys thereof and alloys with silicon, (B) at least two films

30 selected from metal-containing and/or silicon-containing films selected from: metal and/or silicon and metal-oxy and or silicon oxy-materials where the oxy materials are selected from oxides and oxynitrides and where the metal is the same or different and selected from a transition metal of Group , 4,
35 5, 6 or 10 of the Periodic Table of Elements, wherein the protective layer is located in the stack of layers to provide chemical and/or mechanical durability to the stack of layers.

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39.

A coated article of Claim ~~38~~³⁶ wherein the dielectric layer is a first dielectric layer and the infrared reflective layer is a first infrared reflective layer and further including:

a second infrared reflective layer over the second dielectric layer;

optionally a primer layer over the second infrared reflective layer

10 a second dielectric layer over the primer layer; and the protective layer is an overcoat over the second dielectric layer.

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R-126

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40.

A coated article of Claim ~~38~~³⁶ wherein the protective layer is a heat convertible metal located on the substrate before the first dielectric layer.

R-126

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A coated article of Claim ~~38~~³⁶ wherein the protective layer is a heat convertible metal located on the substrate before the first dielectric layer.

R-126

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42.

A coated article of Claim ~~38~~³⁶ wherein the protective layer is a heat convertible metal located between the first dielectric layer and the second dielectric layer below the first reflective layer.

R-126

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A coated article of Claim ~~39~~³⁷ wherein the protective layer has at least two films in either order of metal or silicon and metal oxy material or silicon oxy material located between the second dielectric layer on the reflective layer and a third dielectric layer.

R-126

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44.

A coated article of Claim 1, wherein the protective layer has a thickness for the films of about 5 to about 60 Å for the metal or silicon film and about 20 to about 50 Å, for the oxy-material film.

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~~45.~~ A coated article of Claim ~~44~~⁴², wherein the protective layer has a thickness for the films of 10 to about 30 Å for the metal or silicon film and 30 to 40 Å for the oxy-material film.

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